

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate only, other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (07804-0188), Washington, DC 20503.

1. AGENCY USE ONLY (LEAVE BLANK)		2. REPORT DATE 11 August 1999	
		3. REPORT TYPE AND DATES COVERED Professional Paper	
4. TITLE AND SUBTITLE Air-Launched Glider Delivery Vehicle for Standoff		5. FUNDING NUMBERS	
6. AUTHOR(S) Roger A. Holler			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Air Warfare Center Aircraft Division 22347 Cedar Point Road, Unit #6 Patuxent River, Maryland 20670-1161		8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Naval Air Systems Command 47123 Buse Road, Unit IPT Patuxent River, Maryland 20670-1547		10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.			12b. DISTRIBUTION CODE
13. ABSTRACT (Maximum 200 words) NAWCAD is developing the X-Glider, an expendable aircraft-launched glider vehicle for the air deployment of sensors into denied or contested littoral areas while providing a safe standoff capability to the manned launch aircraft. The X-Glider is the size of a MK-46 torpedo and large enough to accommodate a range of payloads. It can be launched from the wing stations or bomb bay of tactical aircraft. Once launched, the X-Glider's autopilot autonomously guides the unpowered, 14-to-1 glide-ratio vehicle to a predetermined location using GPS to achieve an aircraft standoff distance of 50 nmi, or more, from the hostile environment. The X-Glider is being developed under contract for NAWCAD by AeroVironment, Inc., of Simi Valley, California, and is sponsored by the Office of Naval Research.			
14. SUBJECT TERMS X-Glider Air-Launched Glider Delivery Vehicle Sensors			15. NUMBER OF PAGES 35
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL

Air-Launched Glider Delivery Vehicle for Standoff

Roger A. Holler
Naval Air Warfare Center Aircraft Division
Code 4.5.5.4, Bldg 2185, Suite 1160
22347 Cedar Point Road
Patuxent River, MD 20670-1161

CLEARED FOR
OPEN PUBLICATION

11 Aug 99

PUBLIC AFFAIRS OFFICE
NAVAL AIR SYSTEMS COMMAND

R. Howard

Summary

The Naval Air Warfare Center Aircraft Division is developing the X-Glider, an expendable aircraft-launched glider vehicle for the air deployment of sensors into denied or contested littoral areas while providing a safe standoff capability to the manned launch aircraft. The X-Glider is the size of a Mk-46 torpedo and large enough to accommodate a range of payloads. It can be launched from the wing stations or bomb bay of tactical aircraft. Once launched, the X-Glider's autopilot autonomously guides the unpowered, 14-to-1 glide-ratio vehicle to a predetermined location using GPS to achieve an aircraft standoff distance of 50 nautical miles, or more, from the hostile environment. The X-Glider is being developed under contract for NAWCAD by AeroVironment, Inc., of Simi Valley, California, and is sponsored by the Office of Naval Research.

Background

With the shift in the focus of ASW from open ocean deep water conditions to the littoral shallow water environment, the aircraft will be required to deploy sensors into denied or contested areas. At the same time, the safety of the aircraft and its crew will depend on avoidance of this hostile environment. The use of unmanned vehicles to deploy sensors at a standoff range from the aircraft provides a solution to this dilemma.

UAV's (Unmanned Aerial Vehicles) are being developed in various shapes and sizes, but since they are generally designed to perform missions far more sophisticated than sensor deployment, they are unlikely to be cost effective or readily available for this application. An attractive alternative is an expendable glider capable of being launched from an aircraft at a safe standoff range from the area of interest. The autonomously guided glider would deliver and deploy sensors to their predetermined

destinations and be discarded. The X-Glider, as developed by AeroVironment, Inc., and NAWCAD Patuxent River for the Office of Naval Research, is intended to serve this purpose.

Growing out of a Small Business Innovation Research (SBIR) project, the design concept for the X-Glider was for a vehicle that could be launched from the wing stations or bomb bay of the P-3 Orion or S-3 Viking aircraft, fly to a preset distant destination, and deploy a long horizontal array. The concept required a low cost, expendable glide vehicle with the maximum payload capacity and maximum standoff range. A typical flight path for the X-Glider is shown in Figure 1.

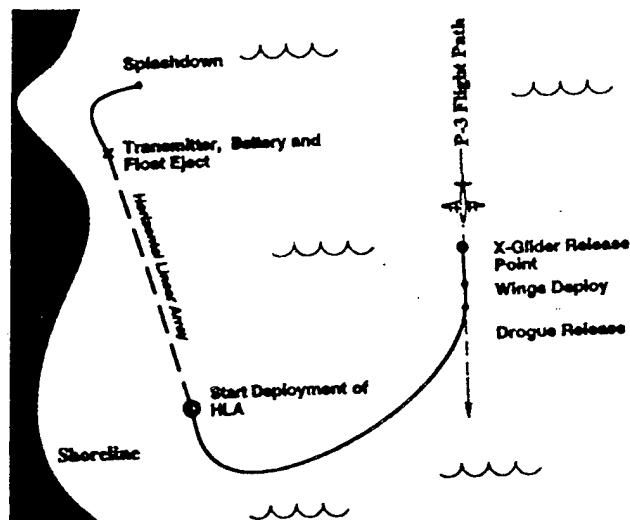


Figure 1: X-Glider Standoff Flight Path

In order to accommodate the largest payload possible, the X-Glider was designed to be similar in size to the Mk-46 airborne torpedo. Its wings would have to be folded or stowed prior to launch and unfolded or opened after launch. Its flight speed would have to be compatible with the realistic speed of deployment of the array. It would also require a guidance system to assure the

placement of the array at the correct location and in the proper orientation.

The Preliminary Design

Several wing configuration types, illustrated in Figure 2, were considered:

- A Para-Wing would require low volume to stow but would only be stable at flight speeds below 30 knots (55.6 km/hr) and could only achieve a maximum glide ratio of 4-to-1,
- A Flexible Membrane Wing would require slightly more volume to achieve up to 60 knots (111 km/hr) and up to a 6-to-1 glide ratio but would have an unstable phugoid mode,
- A Wrap Wing could achieve a glide ratio up to 10-to-1 but would be limited to about 60 knots (111 km/hr), and
- A Rigid Wing could fly at 80 knots (148 km/hr) with a glide ratio between 10-to-1 and 15-to-1.

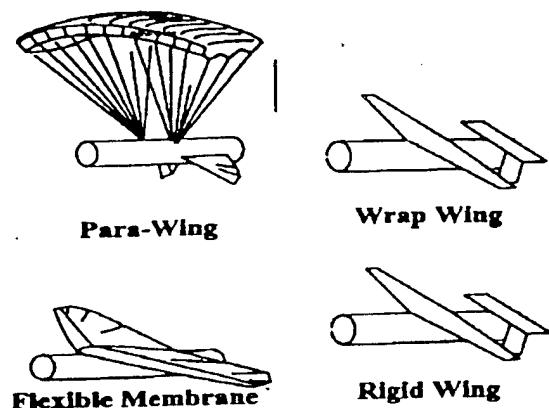


Figure 2: Candidate Wing Configurations

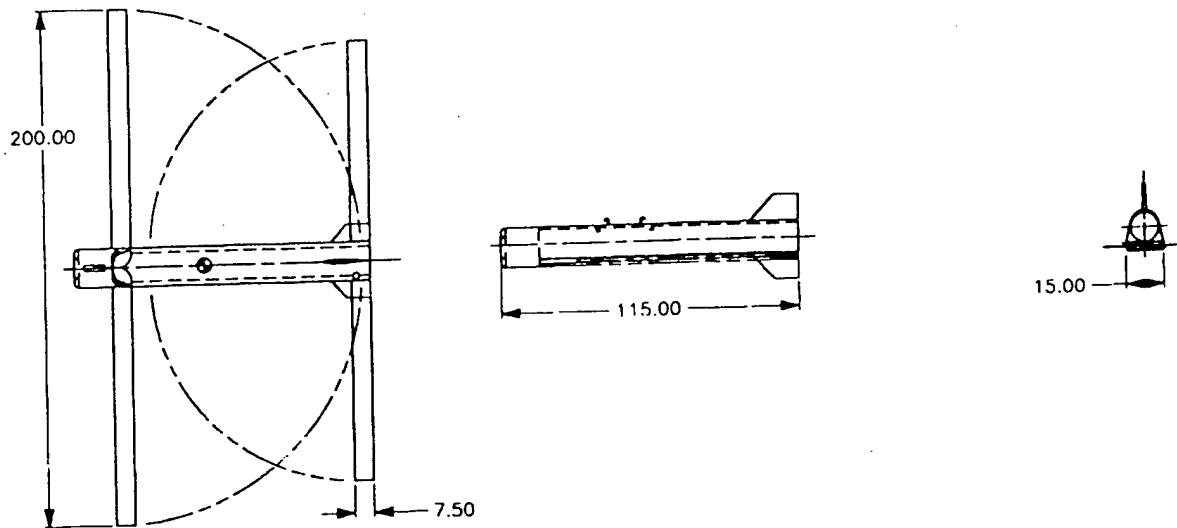


Figure 3: The Baseline X-Glider Configuration (Version 1.0)

The rigid wing provided the best alternative to meet the requirements, and the several different versions were considered, including:

- A Pivot Wing,
- A Pivot Wing with flip-out tips,
- A Swept Swing Wing, and
- A Tandem Wing

Of these, the tandem wing design had the largest wing area, lowest drag, and consequently, the highest lift-to-drag or glide ratio. Analysis indicated that a 14-to-1 glide ratio could be

achieved with this design. The baseline configuration (version 1.0) featured two wings with 7.5-inch (190.5-mm) chords, the front one with a span of 200 inches (5.08 m), six inches (152.4 mm) aft of the nose and the rear one with a span of 170 inches (4.3 m), 107.5 inches (2.73 m) aft of the nose, as shown in Figure 3.

In order to accommodate the largest payload and, at the same time, maintain the highest possible lift-to-drag ratio, the AeroBoost™ nose shape was selected over a traditional low-drag streamlined

nose (for maximum lift-to-drag) or a blunt nose (for maximum payload availability). Shown in Figure 4, while the low-drag streamlined nose avoids flow separation and promotes a laminar boundary layer and the high-drag blunt nose causes separation to turbulent flow, the AeroBoost™ concept prevents separation and results in less than a 2 percent decrease in lift-to-drag ratio over the more streamlined nose. Nearly fifteen percent of the fuselage length would have to have been tapered for the streamlined nose, reducing the volume available for a cylindrical payload by a similar amount.

A 1/12th-scale model was fabricated to evaluate the longitudinal and directional stability of the glider both with and without the wings deployed. The case where the wings were not deployed was of interest to simulate the situation immediately after release of the glider from the wing station or bomb bay. Stability in all cases was good, and it was

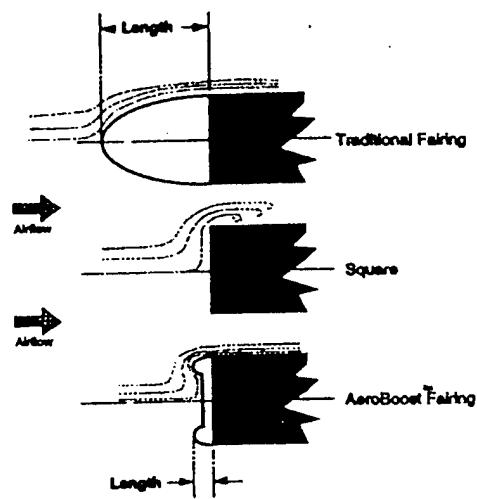


Figure 4: Candidate Nose Designs

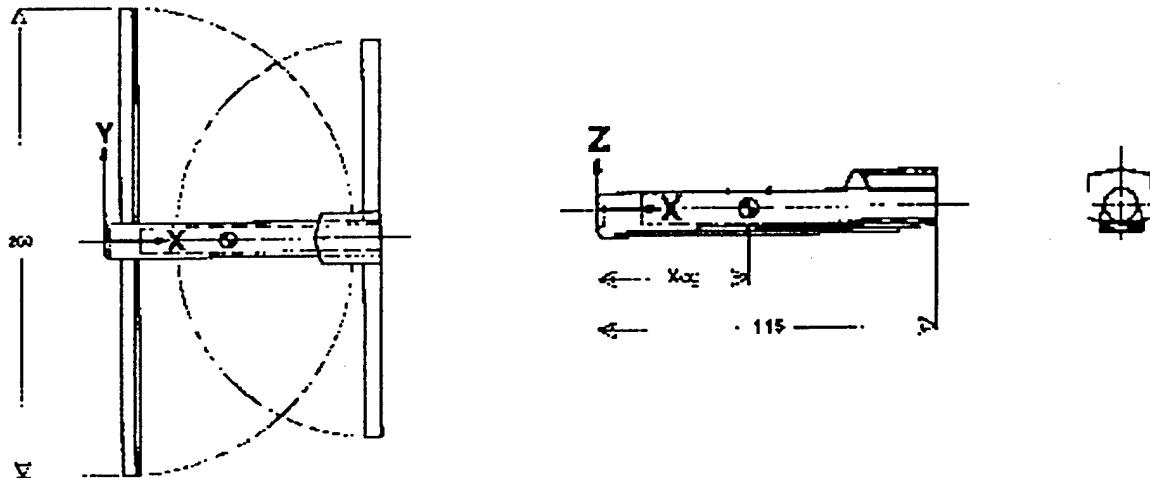


Figure 5: The Revised X-Glider Configuration (Version 1.1)

determined that a horizontal stabilizing fin on the tail was required to prevent roll and oscillations in pitch and yaw. The resulting revised configuration (version 1.1) with the stabilizing fin is shown in Figure 5.

A quarter-scale model, as shown in Figure 6, was fabricated. Initially, it was launched from a hillside catapult (Figure 7), and later, it was suspended (Figure 8) and dropped from a remotely piloted UAV (Unmanned Aerial Vehicle). In both tests, the wings opened in sequence, the rear wings first, and the glider achieved stable flight.



Figure 6: The Quarter-Scale Model

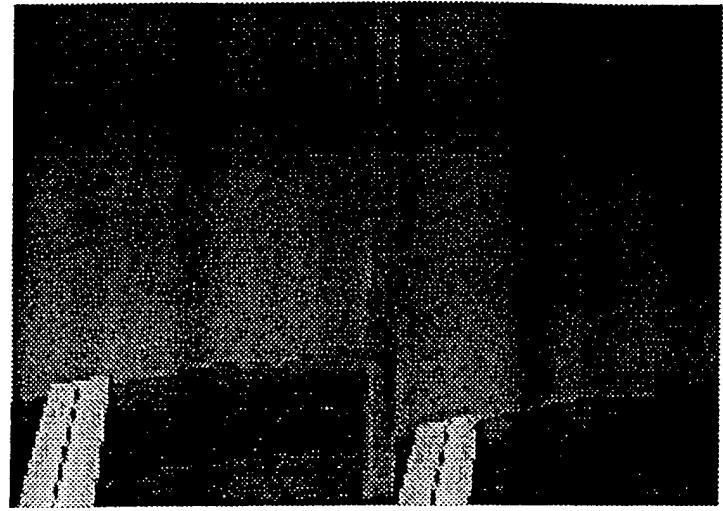
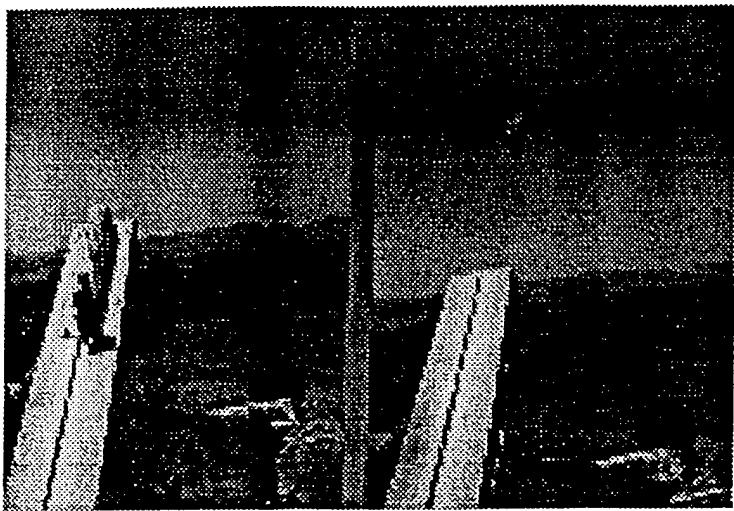


Figure 7: Catapult Launch of the X-Glider Quarter-Scale Model

The Prototype Design

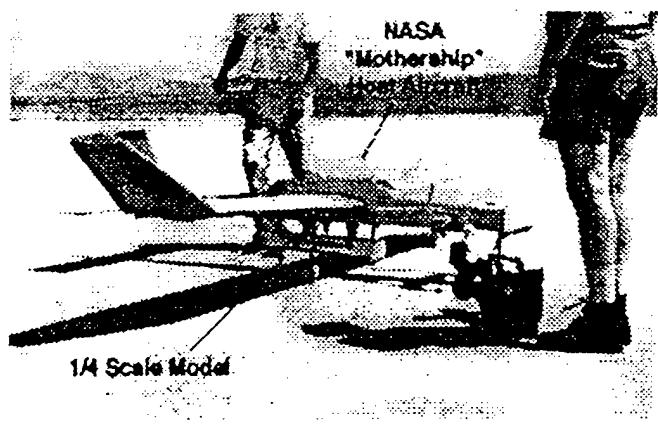


Figure 8: The Quarter-Scale Model on an RPV

Wind tunnel testing conducted at San Diego State University and analysis based on airfoils used in other vehicle developments resulted in the full-scale prototype configuration (version 1.2). There were several changes from the previous version. The wing span for the front wings was slightly shorter to assure proper geometry when the wings were stowed underneath the fuselage and to improve static stability. A 5-degree sweep of both front and rear wings was also influenced by longitudinal static stability. These changes are shown in Figure 9. A positive 6-degree angle of incidence with respect to the fuselage reference line for both front and rear wings was set to optimize the performance of the X-Glider in its cruise phase, maximizing the glide ratio.

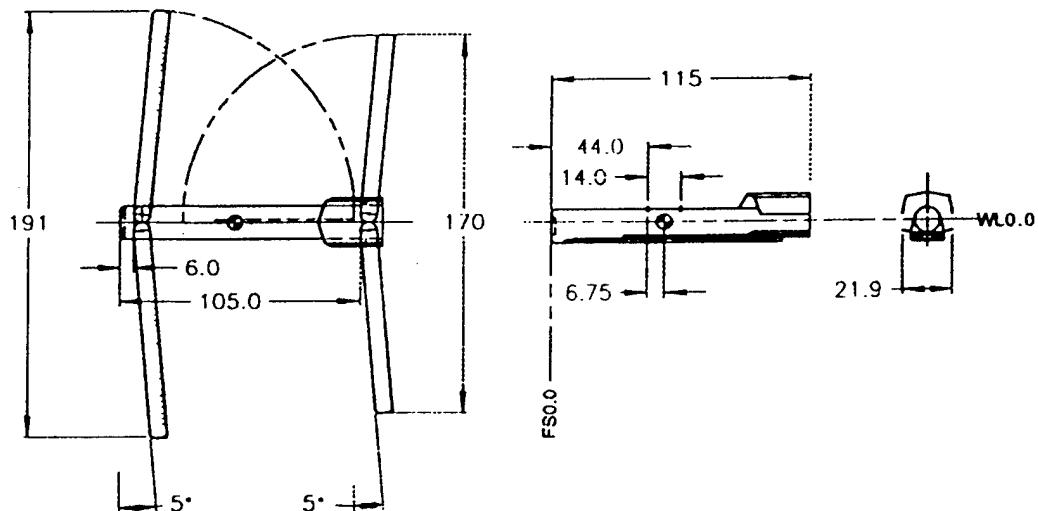


Figure 9: The Final X-Glider Configuration (Version 1.2)

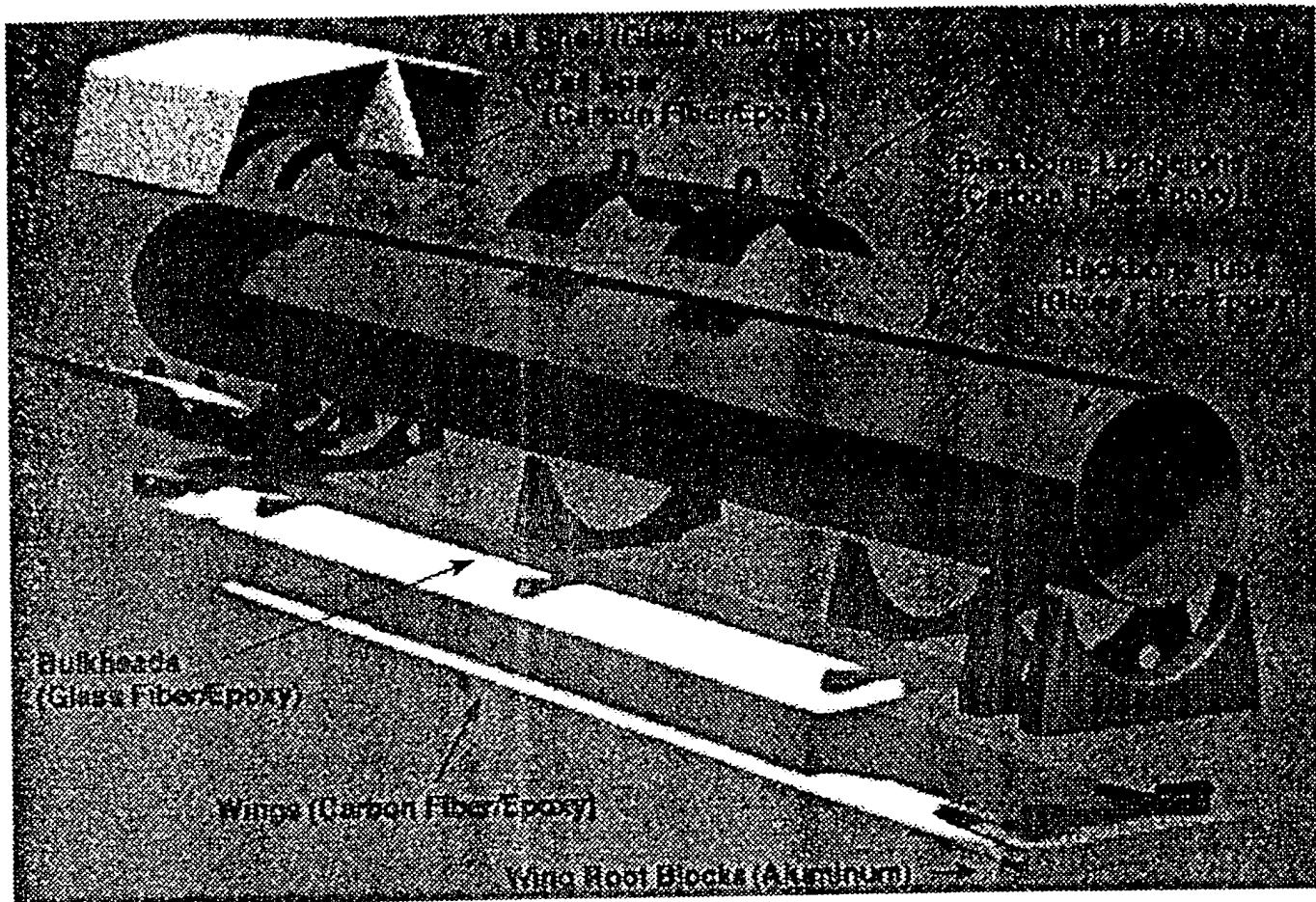


Figure 10: Basic Structural Arrangement of the X-Glider

The requirement for a large lift-to-drag ratio for the wing over a wide range of Reynolds numbers (300,000 to 500,000) led to the selection of the airfoil used in AeroVironment's *Pathfinder* high-altitude, solar-powered remotely piloted aircraft. With the 13.7-percent thickness required for the high aspect ratio wings and a maximum lift coefficient of 1.35, the *Pathfinder* airfoil met all the requirements of the X-Glider.

The fuselage consisted of a long hollow glass fiber-epoxy tube, strengthened with carbon fiber-epoxy longerons and hoops and resting on glass fiber-epoxy bulkheads. As shown in Figure 10, a steel hardback provided the interface for the aircraft suspension lugs. The tail was glass fiber-epoxy, while the wings were made of carbon fiber-epoxy and attached to the aluminum root blocks on the fuselage with aluminum lugs and steel pins. Finally, an aluminum fairing and molded plastic nose enclosed the fuselage, as shown in Figure 11.

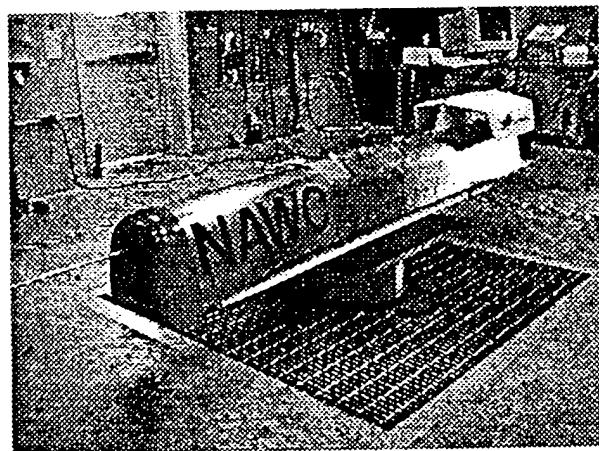


Figure 11: The Fully Assembled X-Glider

Elevons were located on the trailing edges the outer two-thirds of the front wings for flight control by the autopilot, which provides autonomous guidance, stability augmentation, and data acquisition

capability. The autopilot, including the data acquisition subsystem and microprocessor, were packaged for this prototype X-Glider in a 11.8-inch (30.0-cm) long by 7.8-inch (19.8-cm) wide by 4.5-inch (11.4-cm) deep unit, weighing 13 pounds (5.9 kg). The flight control logic consists of three parts: Navigation, Lateral Control, and Longitudinal Control. The features of the sensor inputs to the autopilot are summarized in Table I.

Sensors	Implementation	Remarks
Navigation	OEM GPS engine	C/A, L1 only S/A limited
Heading	Digital 3-Axis Fluxgate Compass	2% of Full Scale max
Rate Sensors Roll Pitch Yaw	Compensated Quartz Rate Sensor (CQRS)	500 deg/sec max +/- 3 deg/sec
Temperature (Avionics)	Monolithic Temp Sensor with integral signal conditioning	-50 to 150 deg Celsius +/- 2% of Full Scale
Temperature (Outside Air)		
Altimeter (pressure)	Compensated Silicon Pressure Sensor	15 to 115kPa +/- 2.5% of VFS
Airspeed (pitot)	Compensated Silicon Differential Pressure Sensor	0 to 100 kPa +/- 2.5% of Full Scale
Accelerometers x-axis y-axis z-axis	Monolithic Accelerometer IC	+/- 4 g max +/- 3.5% of Full Scale
Angle of Attack	Air Data Boom - Vane	+/- 30 deg max +/- 1% of FS
Sideslip Angle		+/- 60 deg max +/- 1% of FS

Table I: Summary of Autopilot Sensors

The navigation system is GPS-based and is used to ensure that the X-Glider follows a specified ground track. Multiple waypoints can be programmed along the flight path to the X-Glider's final destination. The navigation software compares the X-Glider's actual position and heading with the range and bearing to the next waypoint, computes

the cross-track position error, and computes a turn rate and speed commands to keep the X-Glider on course.

The lateral and longitudinal control loops implement these commands. The lateral control loop compares the turn rate command with the actual yaw, roll angle, and roll rate and execute proportional feedback to the elevon for turn rate control. The longitudinal control loop compares the speed command with the actual dynamic pressure, rates of change of dynamic pressure, and pitch rate to execute feedback to the elevons for flight speed control.

Flight Tests

Initial flight tests of a full-scale X-Glider model were conducted on the dry lake bed at El Mirage, California. The test flight model varied from the prototype design in several particulars. The wings were in the open position throughout the tests. Landing gear, initially in the form of two in line wheels and later in the form of a faired front wheel and tail drag member, was added, as shown in Figure 12, so that the X-Glider could be flown and recovered multiple times.

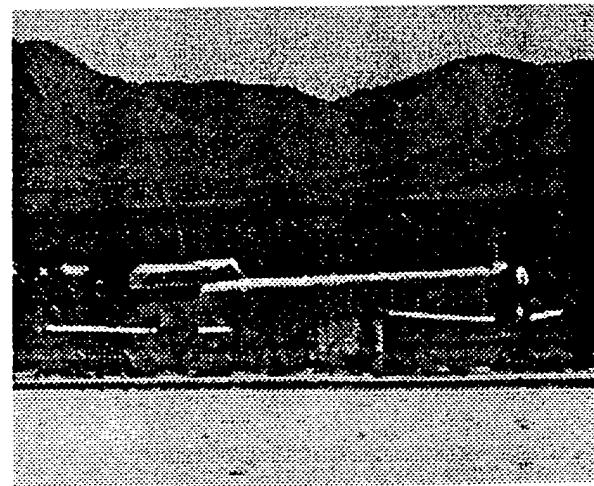


Figure 12: The Recoverable Test Model

The method of launching the X-Glider was to tow it on a 1000-foot (305-m) tether behind a truck. A pilot on the ground had manual rf control of the X-Glider. When the truck reached full speed of 60mph (52 knots or 96.5 km/hr), the X-Glider became airborne, achieving an altitude of approximately 500 feet (152 m). The tether was

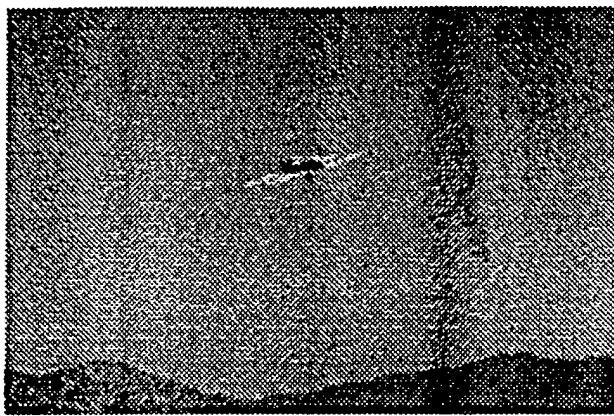


Figure 13: The X-Glider Flying at El Mirage

released and control relinquished to the autopilot. In testing the settings and limits for the autopilot, the pilot initiated maneuvers from which the autopilot was able to recover straight and level flight. As the X-Glider lost altitude, the pilot resumed manual control for a gentle landing. Repeated tests could be performed in this way, testing the characteristics and limits of both the X-Glider and its autopilot. Figures 13 and 14 show the X-Glider in flight.

The full-scale prototype model of the X-Glider was assembled, and multiple on-the-ground tests were conducted to test the initiation of the opening of the wings. Documentation of the results of analyses and tests regarding the configuration, structure, weight and balance, loading, safety, and aircraft interface and separation were prepared by AeroVironment for the Naval Air Systems Team. The Navy generated a flight test plan to fly the X-Glider on the wing station of a P-3 and to launch the X-Glider over the Chesapeake Bay. The X-Glider would be programmed to follow a flight path over water and be recovered by Navy boats and divers. The X-Glider was shipped to the Naval Air Warfare Center Aircraft Division at Patuxent River, Maryland, for the demonstration test. The Characteristics of the X-Glider are summarized in Table II.

Fit tests were conducted to demonstrate that the X-Glider could be safely and properly suspended from the P-3 wing station, as shown in Figure 15. A captive carriage test was performed to evaluate the safety of the P-3 and the integrity of the X-Glider being carried by the P-3 through take off and

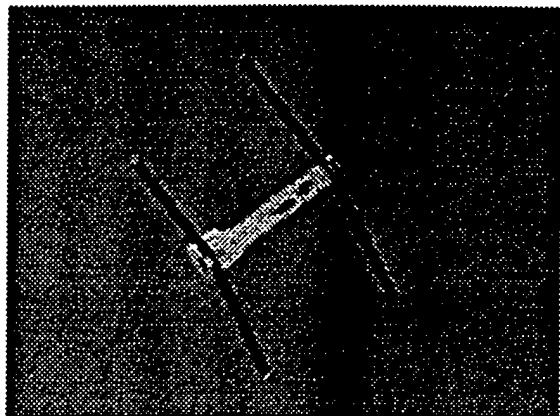


Figure 14: The X-Glider in Flight

landing, as well as under flight conditions. These tests were successful.

Launch	P-3 or S-3 Aircraft Bomb Bay or Wing Station 250 Knots (463 km/hr)
Glide Ratio	14-to-1
Flight Speed	80 Knots (148 km/hr)
Guidance	Autonomous
Navigation	GPS
Size	115 inches (2.92 m) in Length 191 inch (4.85 m) Wingspan
Max Payload	300 pounds (136 kg) 100 inches (2.54 m) Long 11.25 inches (0.286 m) Diameter

Table II: X-Glider Characteristics



Figure 15: The X-Glider on the P-3 Wing Station

The demonstration flight and launch was conducted on 20 April 1999 after a weather delay. Figure 16 shows the planned launch sequence. The P-3 flew the X-Glider at an altitude of 1000 feet (305 meters) and launched the vehicle from wing station 10. The X-Glider separated from the aircraft smoothly and safely. After the lanyard released the wind flap, the pilot chute deployed, followed by the drogue chute. Some roll of the X-Glider was observed before it took a stable right-side-up attitude. The drogue chute jettisoned properly, but the wings failed to open. The vehicle followed a ballistic trajectory into the water, where it broke up on impact. Divers were able to locate and retrieve significant portions of the wreckage.

The failure analysis determined that the burn wires connecting the wing tips and restraining the wings from deploying prematurely as a safety feature had not been initiated by the flight computer. Several possible causes for this failure have been identified, but no definitive determination of the origin of the failure could be made from the data available.

Several additional X-Glider models that include modifications to eliminate the probable failure modes and to incorporate a recovery capability will be fabricated and tested in the near future.

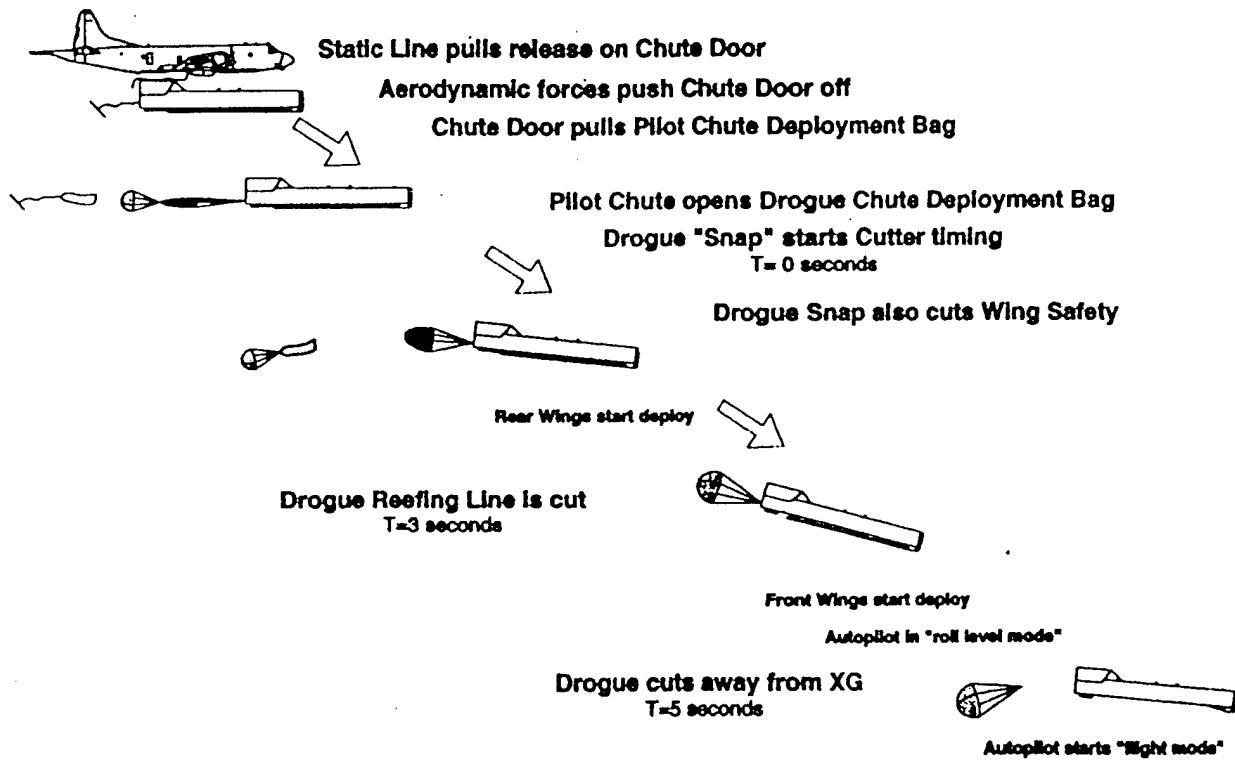


Figure 16: The X-Glider Launch Sequence

Conclusions

The X-Glider, a valuable tool for the rapid air delivery and deployment of ASW sensors from standoff distances, has been designed and developed.

The stable flight and autopilot control of the X-Glider has been demonstrated, and the safe carriage and separation from a P-3 Orion aircraft wing station has been demonstrated.

The X-Glider failed to deploy its wings in the P-3 demonstration test, but there is no indication that the failure was in any way a fundamental fault in the design or an insurmountable obstacle to the performance of the X-Glider.

Additional X-Gliders will be fabricated, including minor modifications to circumvent the likely causes of the observed failure and to address the lessons learned, and subjected to further flight tests.

Air-Launched Glider Delivery Vehicle for Standoff

Roger A. Holler

CLEARED FOR
OPEN PUBLICATION

Naval Air Warfare Center Aircraft Division
Patuxent River, Maryland

11 Aug 99

PUBLIC AFFAIRS OFFICE
NAVAL AIR SYSTEMS COMMAND

H. Harvard

Text of Oral Presentation

At the Naval Air Warfare Center, here at Patuxent River, we are developing an expendable, air-launched, unmanned glider for delivery of sensors into littoral waters to allow the launch aircraft to maintain a safe standoff distance from the contested area.

The development of the expendable glider, or X-Glider, grew out of a Small Business Innovation Research project to disburse sonobuoys launched from ASW aircraft over a wide area, reducing the time for the aircraft to plant a field of sensors. A larger vehicle, about the size of a Mk-46 airborne torpedo, was envisioned to deploy a long horizontal array. The development was sponsored by the Office of Naval Research and done under contract to NAWC by AeroVironment, Incorporated, in Simi Valley California. AeroVironment has been an innovator in air vehicles, having developed the solar-powered, remotely-piloted high-altitude Pathfinder and Centurion aircraft, as well as the human-powered Gossamer Condor and Gossamer Albatross.

The array would be taken to its intended location by the X-Glider and deployed in the air, stretching out the long line as the glider continued to fly. Once the array was all paid out, the X-Glider would splash down. With the GPS guidance, the course of the glider and the orientation of the array could be predetermined. The aircraft could fly along some distance, possibly 50 miles, off a coastline, and launch the X-Glider. Using its own guidance and autopilot, the X-Glider would fly a course to deploy the array in the area of interest.

Once released from the aircraft bomb bay or wing station, the X-Glider is slowed down to around 80 knots by a drogue chute. Once the wings deploy, the drogue chute is jettisoned and the X-Glider flies to its destination to deploy its array.

The first part of the X-Glider development focused on a quarter-scale model to evaluate the best design to achieve a high glide ratio, high speed, and good stability. The wings needed to be stowed in or under the fuselage for carriage on the aircraft. The design that was selected was that of a tandem wing vehicle.

After wind tunnel tests, the model was launched using a catapult to demonstrate the wing deployment in flight.

Later, the quarter-scale model of the X-Glider was mounted beneath a remotely piloted vehicle, taken to altitude, and released. The model successfully deployed its wings and flew. The elevons on the front wings allowed the glider to be controlled over a radio link by a pilot on the ground, who landed it on the flat bed of a dry lake.

The X-Glider design had a 14-to-1 Lift-to-Drag, or Glide Ratio. Launched from an altitude of 20,000 feet, it could achieve nearly 50 nautical miles of range, and from 30,000 feet, the range would be 70 nautical miles.

The characteristics of the full-size X-Glider were these. It could be launched from either the bomb bay or the wing station of the P-3 Orion or the S-3 Viking aircraft, fly with a 14-to-1 glide ratio at a speed of 80 knots, have an autonomous guidance system with GPS, be the size of a Mk-46 torpedo, carrying a payload of up to 300 pounds in a cylindrical volume 100 inches long by 11.25 inches in diameter.

After several iterations based on additional wind tunnel tests, the configuration featured wings that were swept back at a 5-degree angle, each having a positive incidence angle of 6 degrees. The span of the front wings was 191 inches and the rear wings, 170 inches. The nose was an aerobost nose design, similar to fairings for tractor-trailer trucks, to reduce drag and still achieve a maximum payload capacity.

The X-Glider was constructed largely of glass fiber/epoxy reinforced with carbon fiber/epoxy, with the wings made of carbon fiber/epoxy rooted in aluminum blocks with a steel pin. Over all of this was placed an aluminum skin.

The first full-size model had landing wheels so a number of flight tests could be conducted. The testing took place at the El Mirage dry lake in California. The X-Glider was towed, wings open, on a 1000-foot line behind a truck. As the truck attained speed, the glider became airborne, achieving an altitude of 500 feet. The towline was released and the X-Glider flew.

The performance and limits of the autopilot aboard the X-Glider was tested by an on-the-ground pilot who could maneuver the glider, then relinquish control to the autopilot, which would have to recover.

The X-Glider was very stable and flew well.

For landing, the on-the-ground pilot resumed control to assure a gentle landing, though this was not without mishaps.

The full-scale prototype of the X-Glider was assembled and a sequence of tests was performed on the ground to demonstrate the wing opening and all the mechanisms that initiated it. The X-Glider was then shipped to Patuxent River and fitted to a wing station on a P-3. Flight clearance was obtained and it was flown on the wing station in a captive carry test without problems.

The final flight demonstration test was initiated over the Chesapeake. The X-Glider was mounted on wing station 10 of a Patuxent River P-3. Cameras were mounted on adjacent wing stations. The X-Glider was released. As it fell away from the aircraft, a lanyard released a cover on the aft of the X-Glider, which acted as a wind flap, pulling out a small pilot chute, which in turn pulled out the drogue chute to slow down the glider. The drogue line tension initiated mechanically activated cable cutters that severed a safety line, which had secured the wings. This was the first of two safety devices to prevent premature wing opening while the X-Glider was still attached to the P-3. Also, a timing circuit was supposed to be initiated that burned a wire holding the wing tips together, as a second safety feature. At that point, the rear wings were to open. After 3 seconds, the front wings were to deploy. After 5 seconds, the drogue was jettisoned, at which time, the autopilot was to take over. Unfortunately, the second safety on the

wings did not initiate, the wings did not open, and the X-Glider followed a ballistic trajectory into the bay.

Divers recovered most of the wreckage of the X-Glider, and it was determined that the burn wire which secured the wing tips had not burned and prevented the wings from opening. The flight computer was unable to provide information as to the exact cause of the problem - although several possibilities are being looked at, with the objective of eliminating the potential causes of the failure in future X-Gliders. Small things can have disastrous effects in a development of this kind, but it is all a part of Research and Development. The good news is that the X-Glider flew on the P-3 without incident and separated cleanly. The X-Glider had previously been shown to fly well with autopilot control. It remains to demonstrate the transition from wings closed to wings open, which has been done on the ground, will take place properly in the airstream.

Additionally, deployment of sensors and arrays from the X-Glider needs to be developed and demonstrated. With its 100-inch long, 11.25-inch diameter payload capacity, it accommodates a triangular arrangement of 3 A-size cylinders. Arrays might be packaged in long A-size diameter tubes, interconnected A-size diameter tubes, or be of a size that fills the entire glider.

Discrete packages can be deployed as well, including 6 A-size sonobuoys, 3 long A-size diameter units, or sensors with diameters up to 11.25 inches.

An interface to accommodate 6 A-size sonobuoys launched by CAD's is being investigated.

Despite the setback resulting from the failure over the Chesapeake Bay, we are going ahead with plans to resolve the problem and fly again. Two more X-Gliders will be fabricated. They will have changes incorporated in them to avoid the failure mode observed, and they will be recoverable and reusable. We intend to use these X-Gliders to demonstrate deployment of various type sensors and to demonstrate the full sequence of X-Glider launch and autonomous flight.

The X-Glider represents an opportunity to deploy sensors rapidly and accurately from a standoff aircraft. It has the advantage of being small and easily transported anywhere quickly, without special requirements. Because it will be expendable and low cost, it will be readily available for missions like sensor deployment, which might not be true for high cost, reusable UAV's produced in relatively small quantities. With a low radar cross-section, no engine to produce an infrared or acoustic signature, and no propellers to generate high Doppler, the X-Glider should exhibit low observability.

We believe that there is a multitude of uses for the X-Glider as a standoff delivery vehicle beyond the realm of anti-submarine warfare. Through the development of alternative and joint applications, the affordability of the X-Glider will be increased.



Air-Launched Glider Delivery Vehicle for Standoff

CLEARED FOR
OPEN PUBLICATION

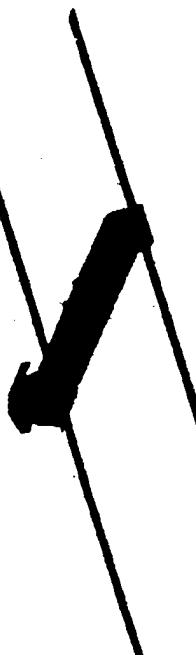
11 Aug 79

PUBLIC AFFAIRS OFFICE
NAVAL AIR SYSTEMS COMMAND

J. Howard

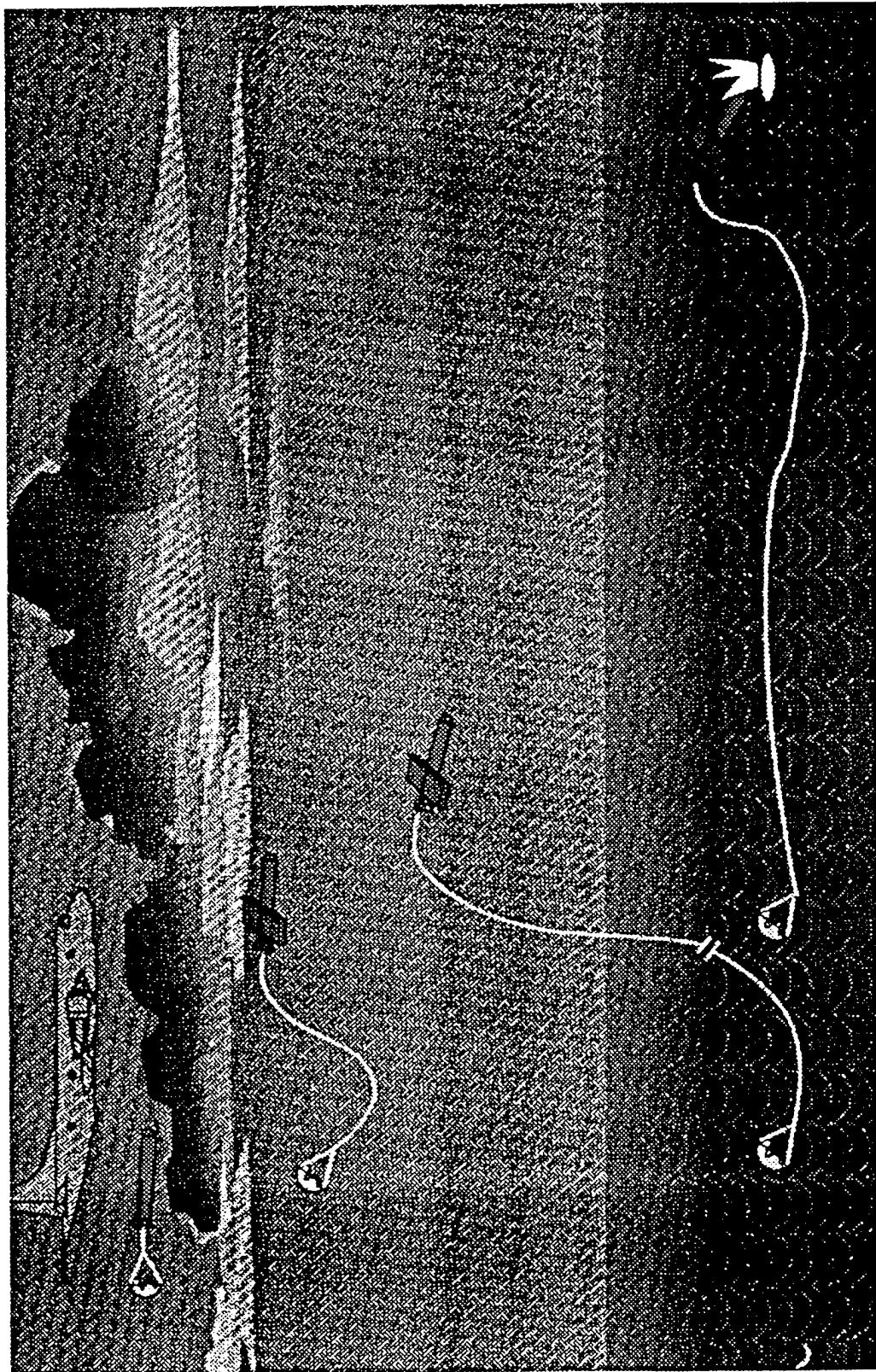
Roger A. Holler

Naval Air Warfare Center Aircraft Division
Patuxent River, Maryland

PHASE I		PHASE II		PHASE III	
Mar '88 . . .	Dec '88	Aug '89 . . .	Sept '92	Sept '95 . . .	Dec '96. Mar '97 . . .
					
Expendable Glider Length: 6' Span: 24' LD: 21 Weight: 2.1 lbs	Expendable Glider Length: 36' Span: 36' LD: 10' Weight: 10 - 40 lbs	X-Glider Length: 115' Span: 200' LD: 141 Weight: 450 lbs			
VLC Sonobuoy 1.5 lbs 4.5" diameter 6" Length	"A" sized Sonobuoy 15 - 40 lbs 36" length 4.86" length	HLA 225 lbs 100" length 11" diameter	Payload <350 lbs 100" length 11" diameter	<ul style="list-style-type: none">• Phase III, Part 1	<ul style="list-style-type: none">• Phase III, Part 2• Phase III, Part 3
<ul style="list-style-type: none">• Phase I SBIR	<ul style="list-style-type: none">• Phase II SBIR	<ul style="list-style-type: none">• Developed system concept for delivery of HLA• System design	<ul style="list-style-type: none">• Wind Tunnel Test• Full-Scale Flying Prototype• Demonstrate Launch from P-3• Autonomous Flight	<ul style="list-style-type: none">• Extensive Flight Test• Payload Integration	
<ul style="list-style-type: none">• Developed method for dispersion of VLC sonobuoy• Evaluated and tested several configurations	<ul style="list-style-type: none">• Built and tested wind tunnel and flight prototypes for delivery of "A" sized sonobuoy• Demonstrated launch from P-3 of viable low cost system	<ul style="list-style-type: none">• 1/4 scale flying model• Full-scale mock-up			

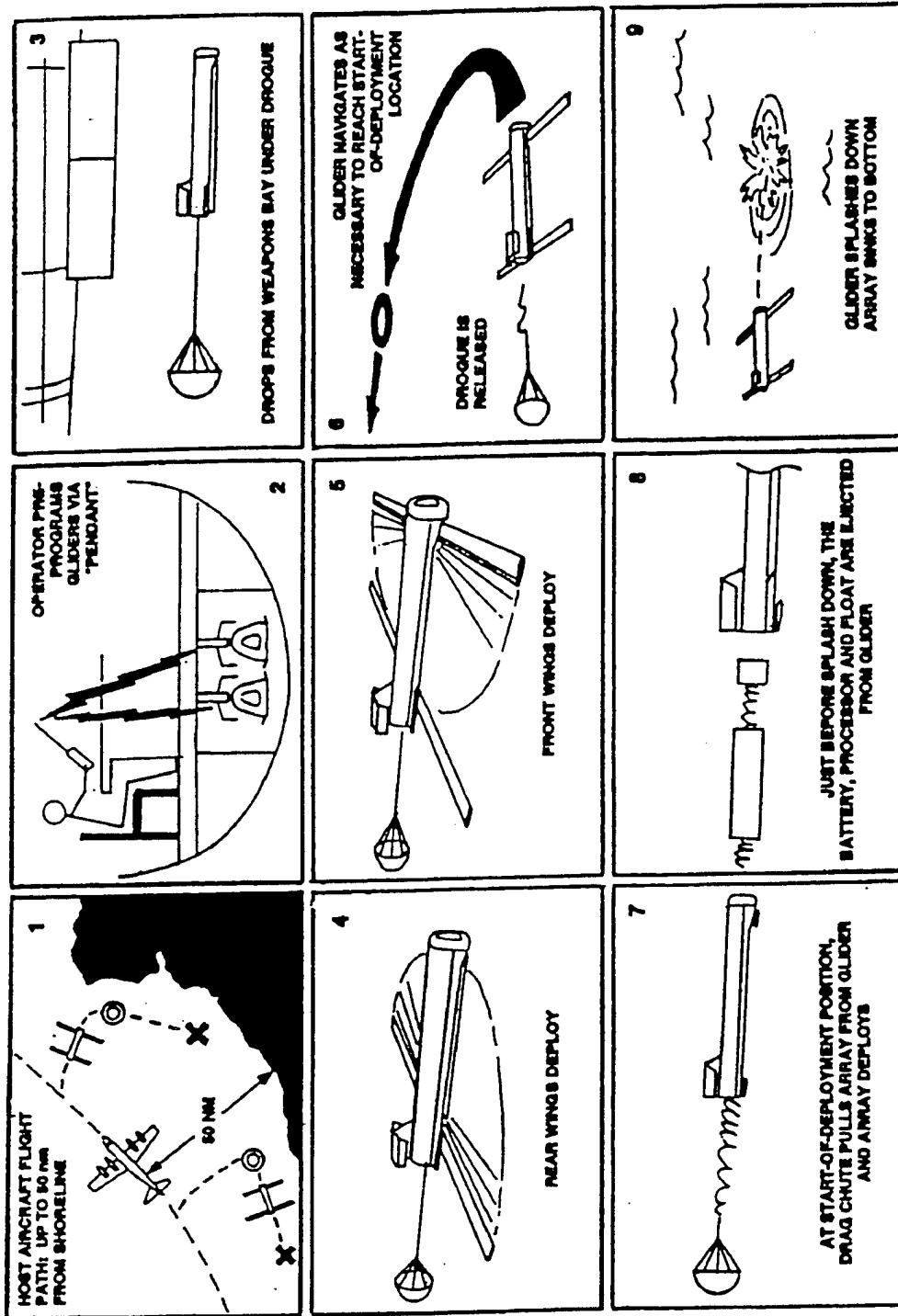


X-GLIDER Array Deployment



X-GLIDER

Deployment Sequence

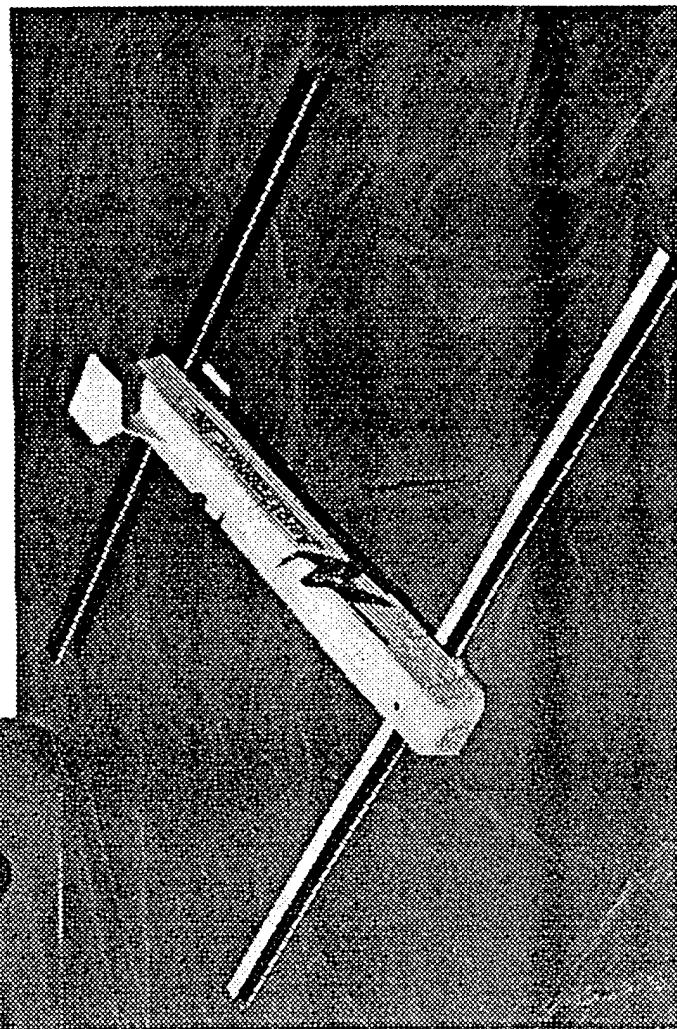


FULL SCALE PAYLOAD

WEIGHT - 250 LBS LENGTH - 100 IN DIAMETER - 11.25 IN



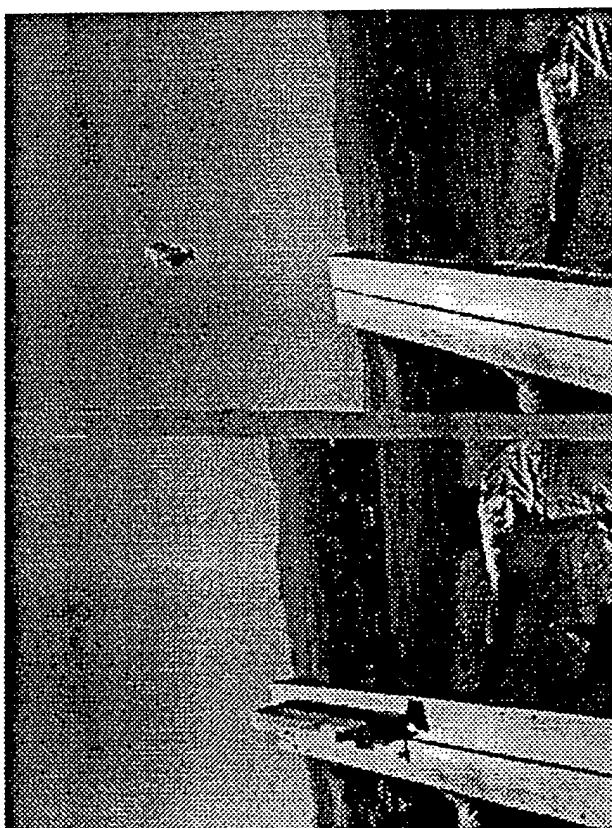
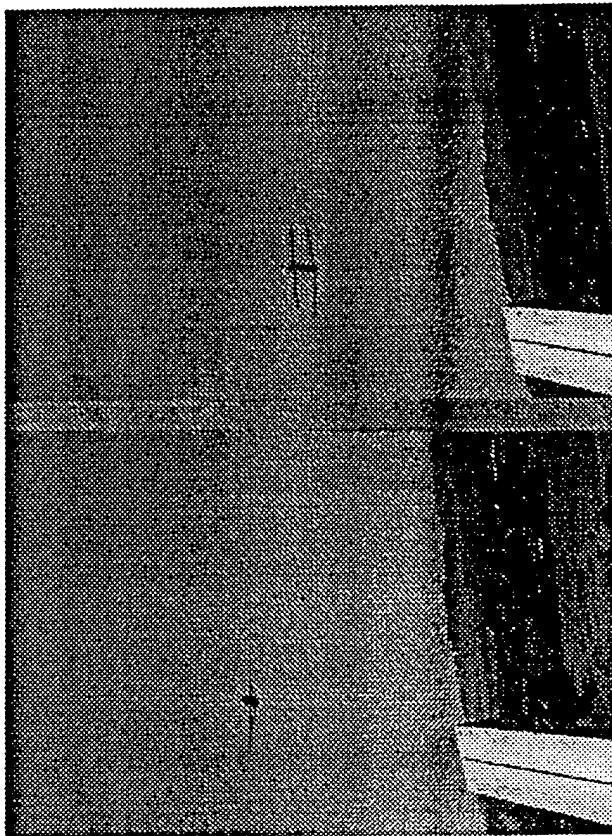
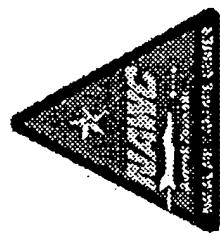
1/4-SCALE
X-GLIDER
WITH WINGS
RETRACTED



1/4-SCALE
X-GLIDER
WITH WINGS
DEPLOYED



CATAPULT LAUNCH
OF
QUARTER-SCALE X-GLIDER





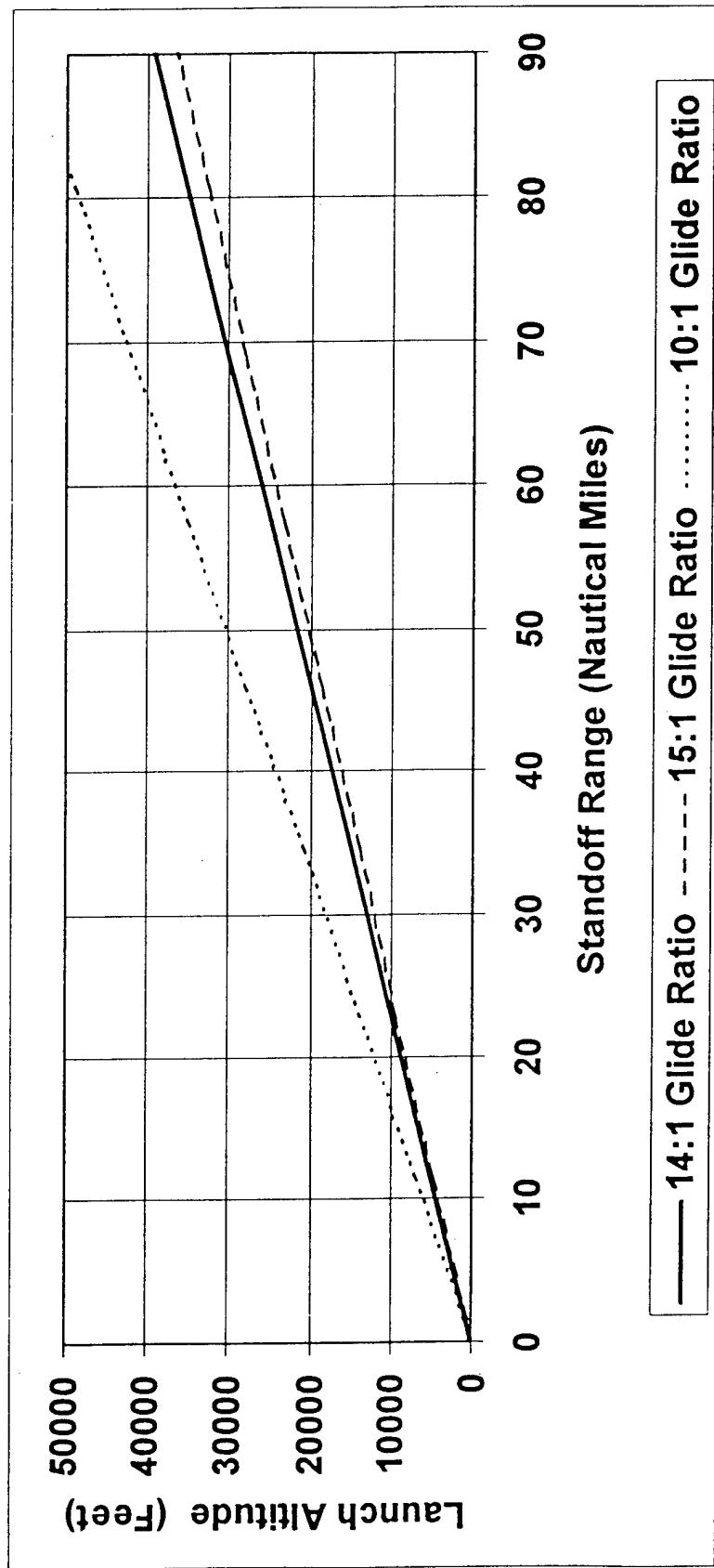
X-GLIDER

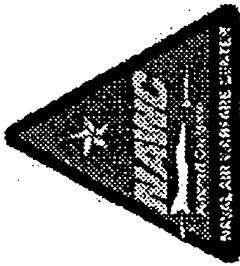
Quarter-Scale Model on RPV



X-GLIDER

Standoff Range



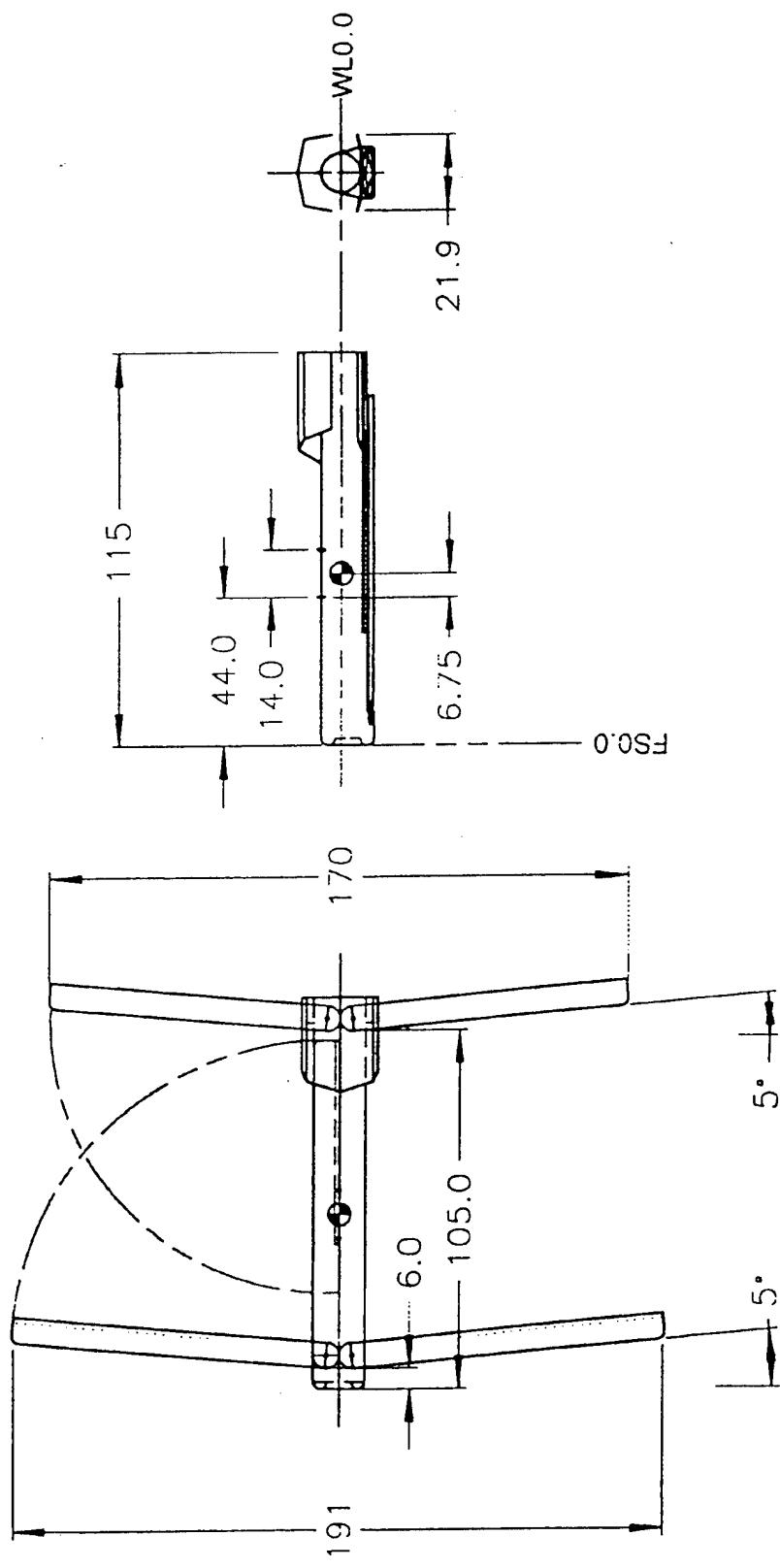


X-GLIDER Characteristics

- **Launch**
P-3 or S-3 Aircraft
Bomb Bay or Wing Station
- **Glide Ratio**
14-to-1
- **Flight Speed**
80 Knots (148 km/hr)
- **Guidance**
Autonomous
- **Navigation**
GPS
- **Size**
115 inches (2.92 m) in Length
191 inch (4.85 m) Wingspan
300 pounds (136 kg)
- **Max Payload**
100 inches (2.54 m) Long
11.25 inches (0.286 m) in Diameter



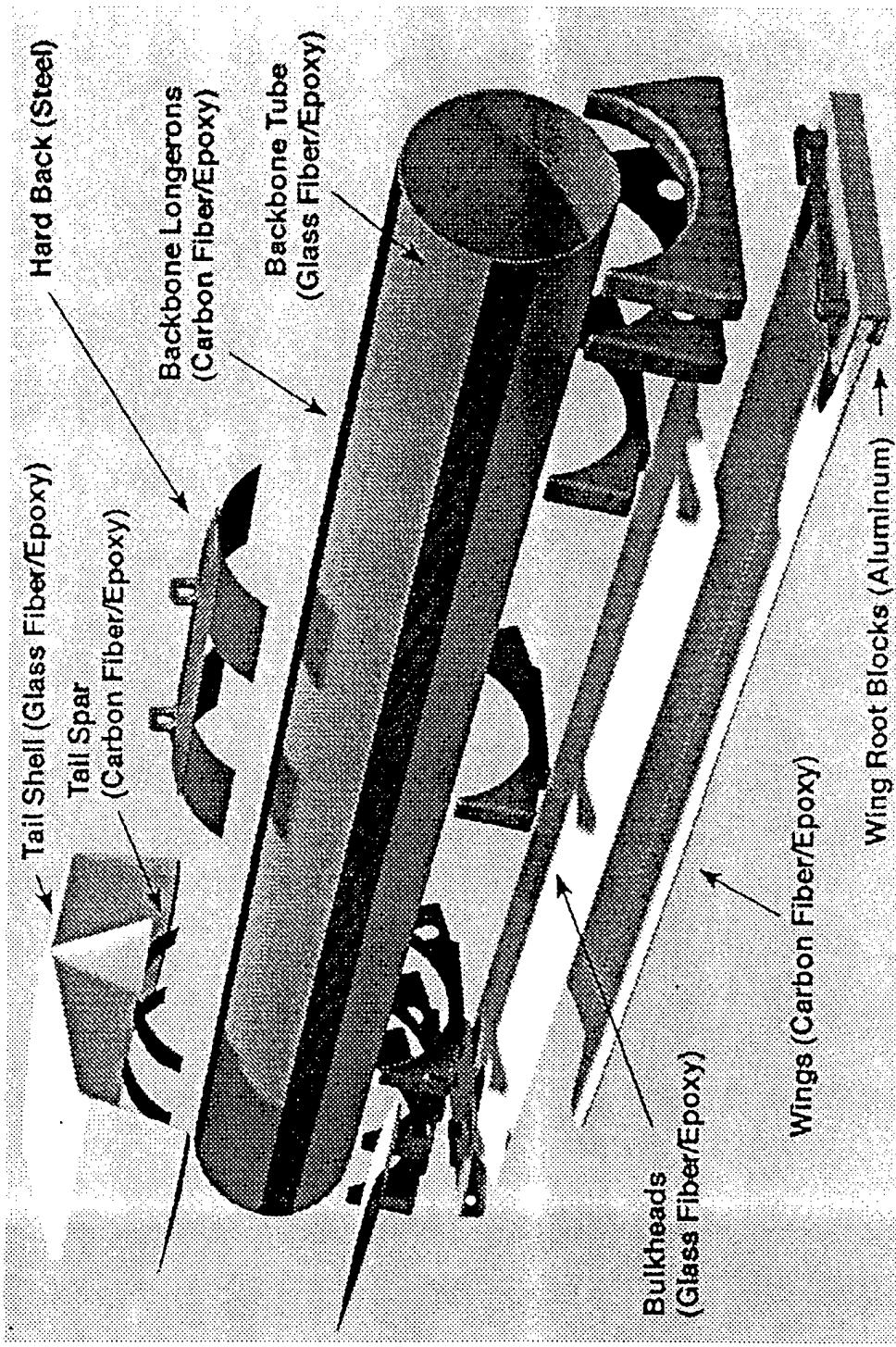
X-Glider Configuration





X-GLIDER

Exploded View Basic Structural Arrangement



X-GLIDER

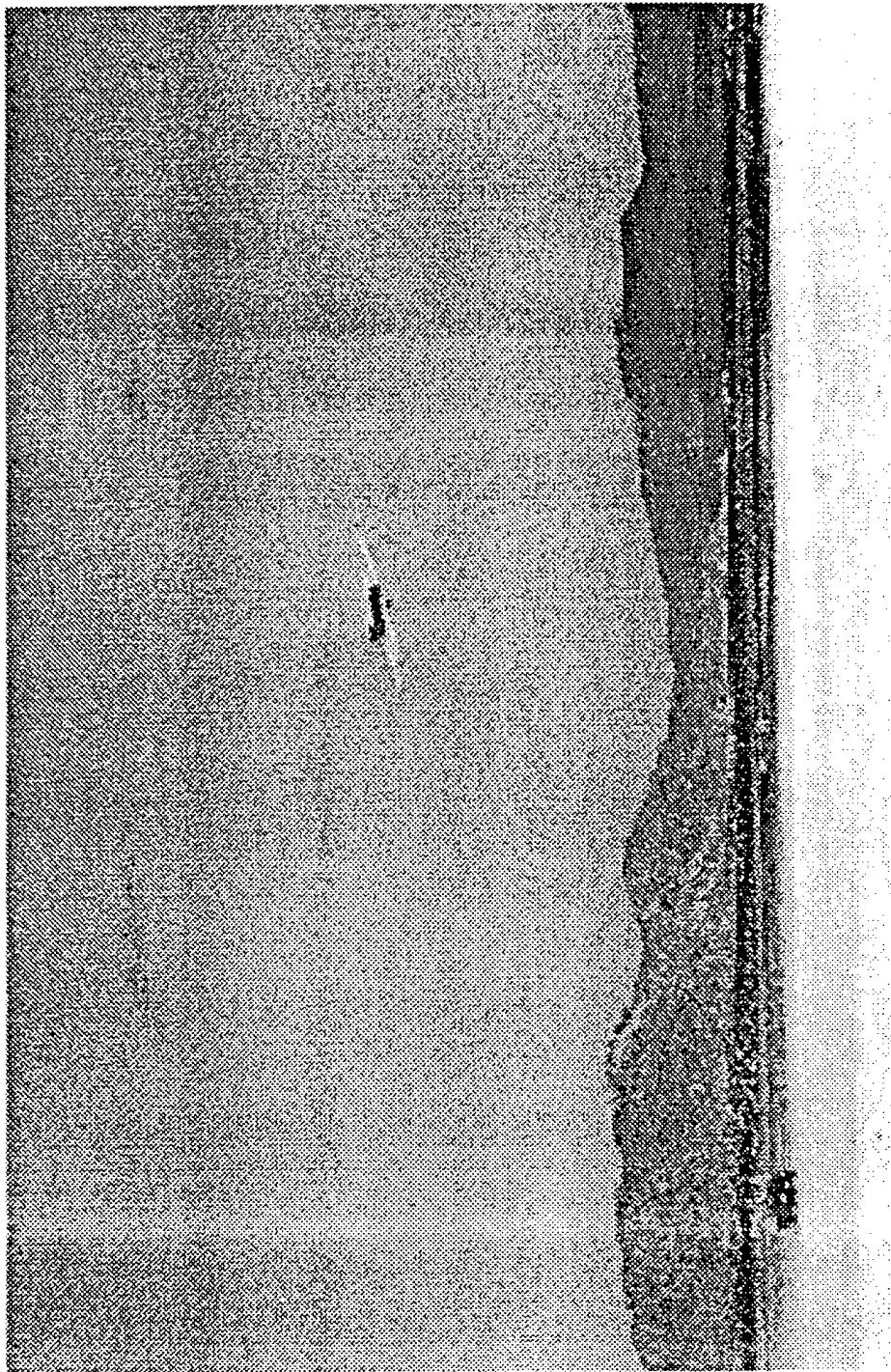
FULL SCALE TEST MODEL (EL MIRAGE DRY LAKE)





X-GLIDER

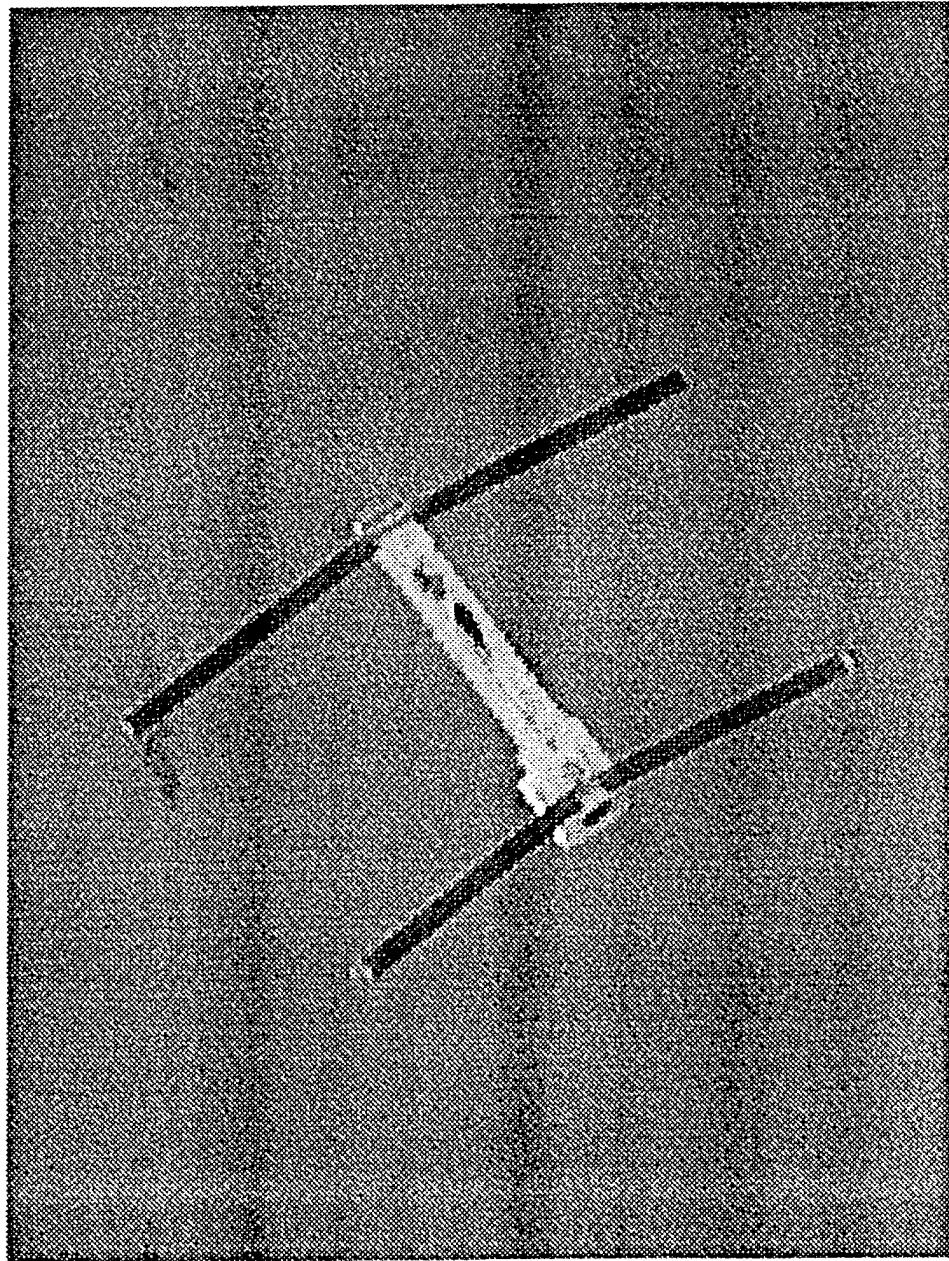
FULL SCALE MODEL IN FLIGHT



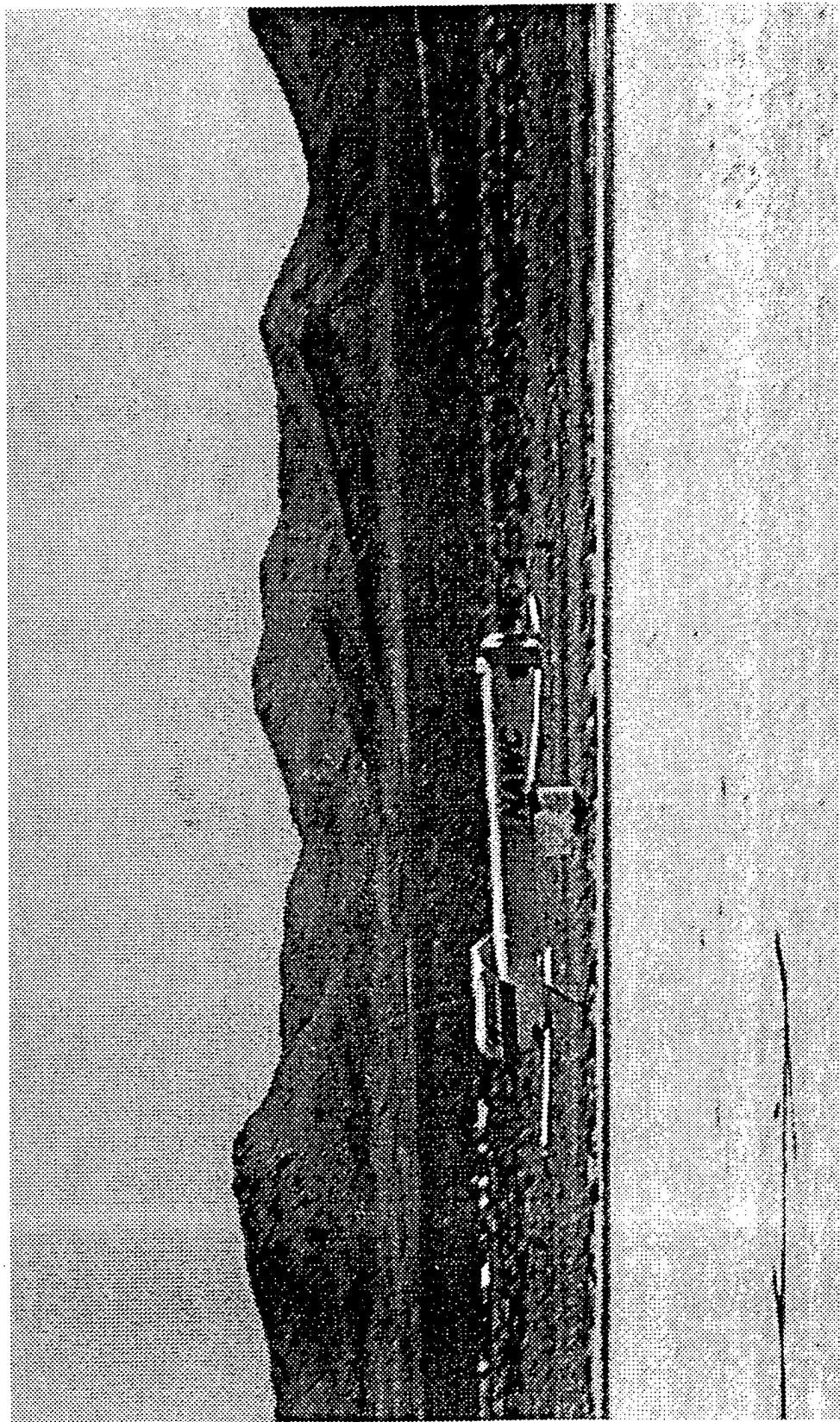


X-GLIDER

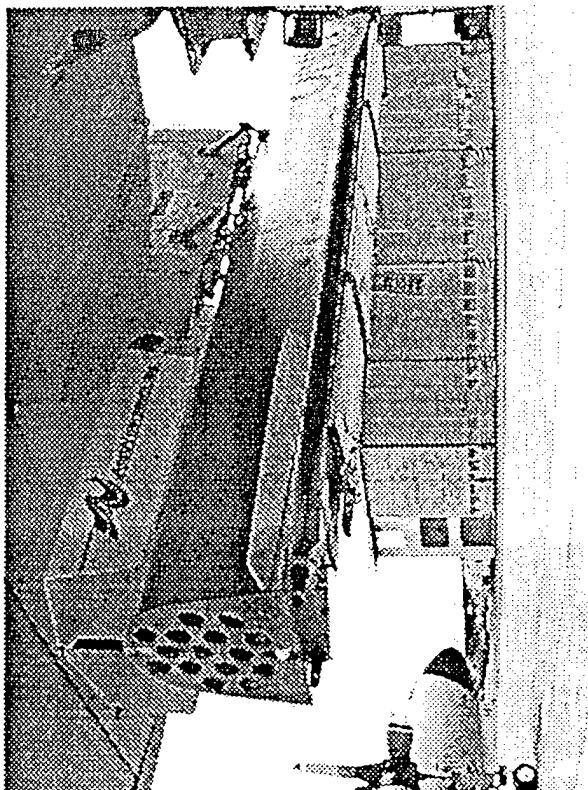
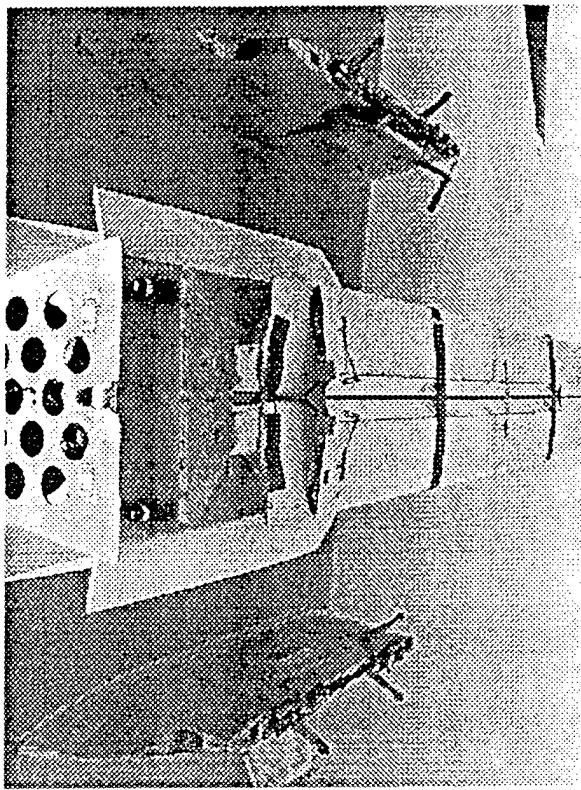
FULL SCALE TEST MODEL IN FLIGHT



FULL-SCALE X-GLIDER
EL MIRAGE DRY LAKE TEST



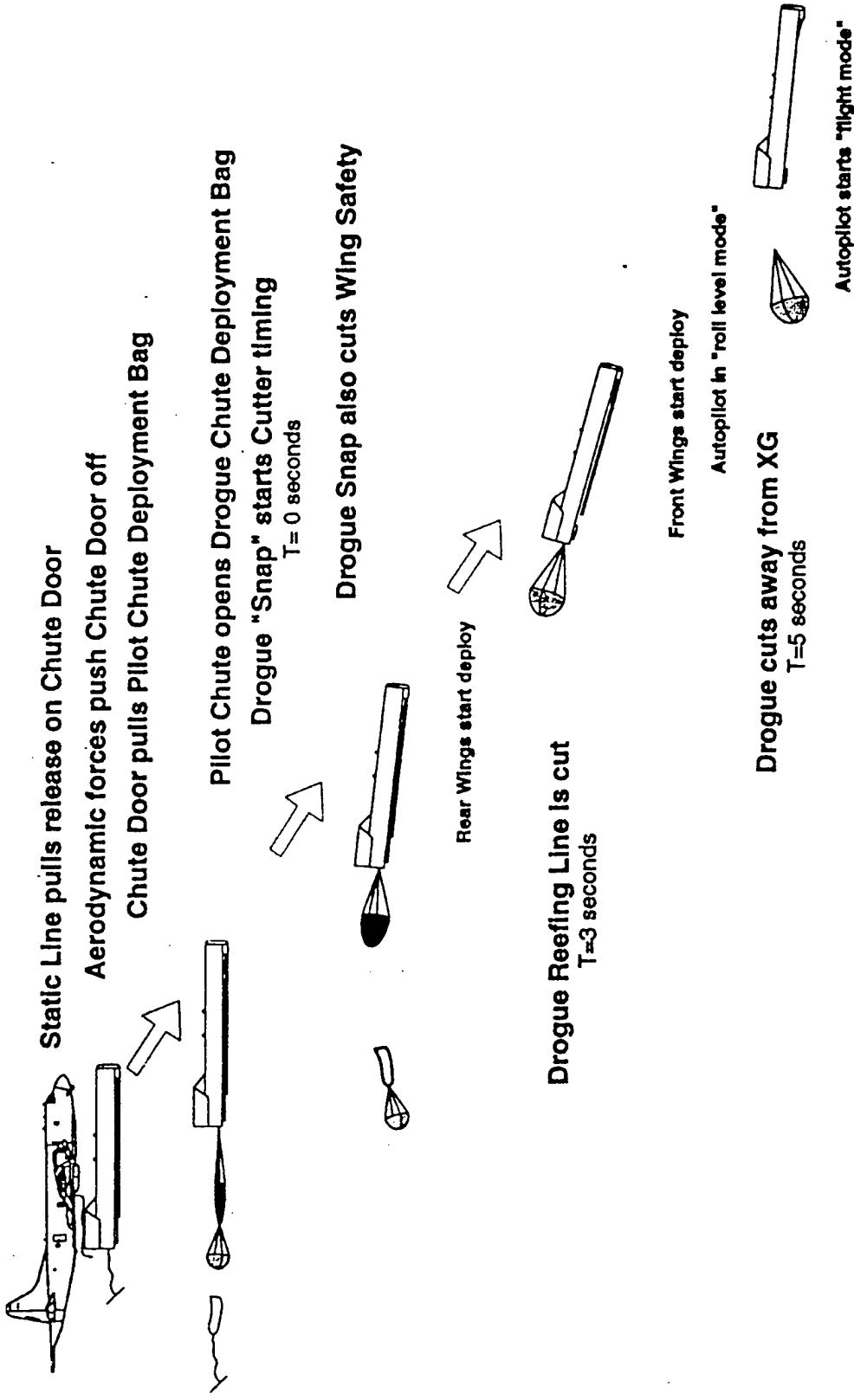
PROTOTYPE X-GLIDER ON WING OF P-3





X-GLIDER

Deployment from the P-3



PROTOTYPE X-GLIDER AFTER RECOVERY



The Launch Interface for Long Arrays Can Accommodate:

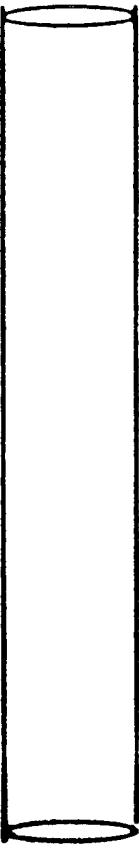
(a) 3 individual arrays each from a single A-size diameter unit up to 100 inches in length



(b) One continuous array packaged in 3 interconnected A-size diameter cylinders up to 100 inches long

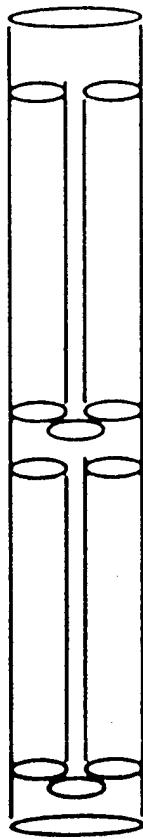


(c) One continuous array packaged to the 11.25-inch diameter payload capacity of the X-Glider

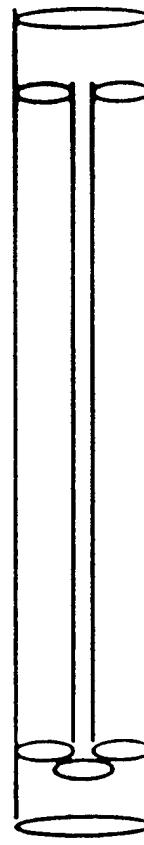


The Launch Interface for Discrete Sensors Can Accommodate:

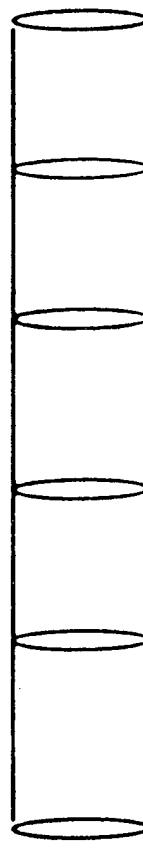
(a) 6 A-size diameter units with lengths less than 45 inches



(b) 3 sensors of A-size diameter more than 45 inches long but less than 92 inches long

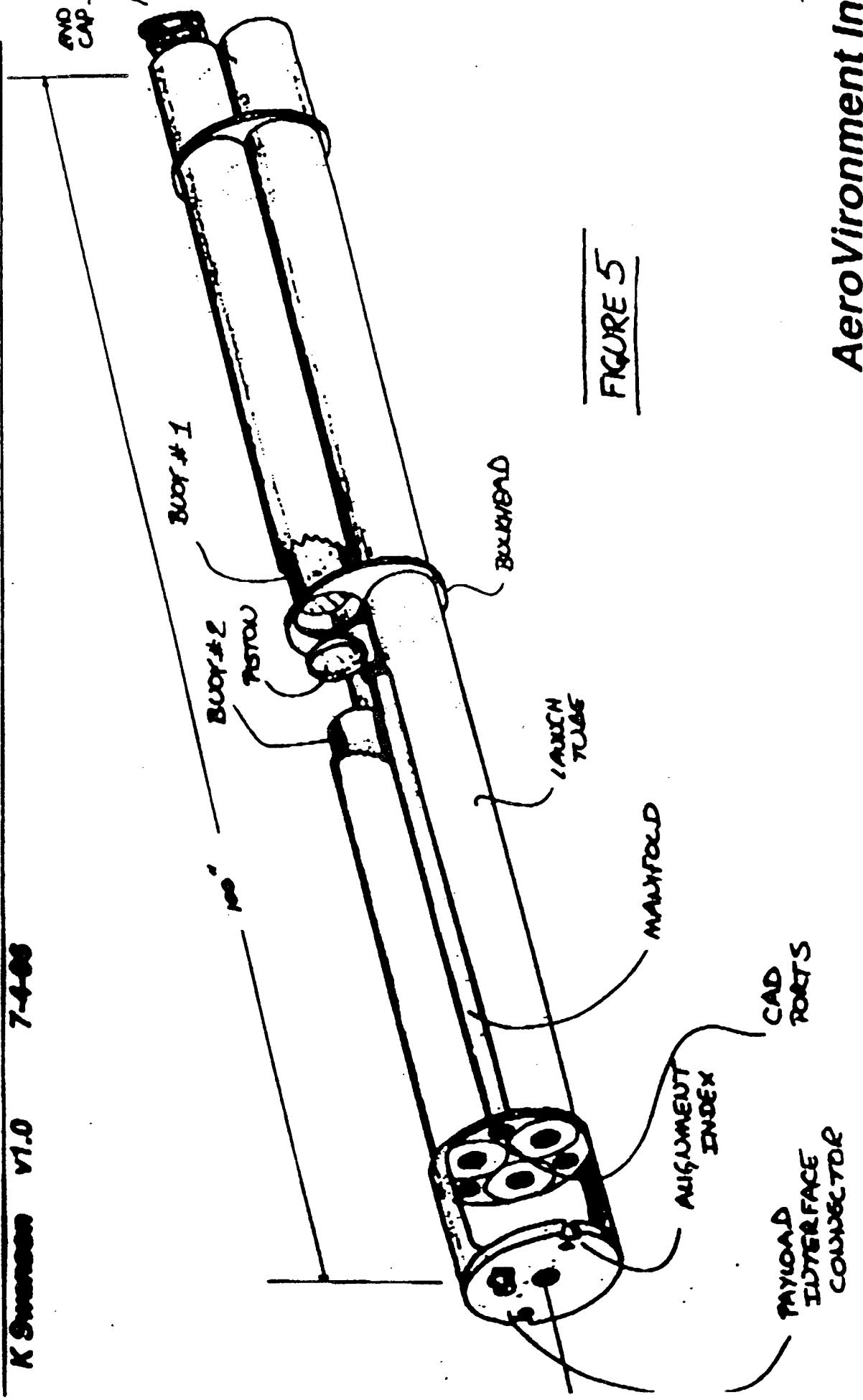


(c) Multiple sensors packaged in larger diameters up to 11.25 inches



X-Glider "A" Sized Payload Cartridge

K Sensors v1.0 7-4-98



AeroVironment Inc



X-GLIDER

Future Plans

- Change Order to AeroVironment Contract to Build:
2 Full-Scale Test Models of the X-Glider
Incorporating Improvements and Recovery Capability
- Develop and Implement X-Glider Interfaces and Deployment Methods for the Launch of Discrete Sensors and Deployment of Long Arrays
- Demonstrate Sensor Deployment from the X-Glider
- Demonstrate Full Sequence of Aircraft Launch, X-Glider Flight, Autonomous Guidance, and Sensor Deployment



ADVANTAGE OF GLIDERS

- RAPID DEPLOYABILITY
 - SMALL, TRANSPORTABLE, VERSATILE
 - NO LARGE LOGISTICS TRAIL
 - NO RUNWAYS, SUPPORT TEAMS, REFURBISHMENT
- LOW COST
 - EXPENDABLE, UNPOWERED
 - PRODUCTION COST NOT AMORTIZED
 - AVAILABLE FOR MISSION
- LOW OBSERVABILITY
 - LOW RCS
 - NO IR, ACOUSTICS, HIGH DOPPLER COMPONENTS

X-GLIDER PRODUCT LINES

